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150 Reykjavík

11. desember 1989

Kæri Hörður.

Stjörnufræði hefur um langan aldur verið skyldugrein í "stærðfræðideildum" margra íslenskra menntaskóla og hún er víða á námsskrá framhaldsskóla sem valgrein. Það vekur því óneitanlega nokkra athygli að greinarinnar er hvergi getið í bókinni **"Námsskrá handa framhaldsskólum. Námsbrautir og áfangalýsingar"** (2. útgáfa, apríl 1987) sem framhaldsskóladeild Menntamálaráðuneytisins gefur út. Af samtölum við ýmsa aðila má ráða að stjörnufræðin hafi einfaldlega gleymst og hér sé því ekki um vísvitandi stefnubreytingu að ræða. Til að taka af skarið um þetta atriði leggjum við til að í næstu útgáfu námsskrárinnar verði birtar lýsingar fyrir áfanga í stjörnufræði.

Stjórn Stjarnvísindafélagsins vill leggja sitt af mörkum til þess að hraða framgangi málsins. Með bréfi þessu eru því sendar tillögur okkar að lýsingum tveggja stjörnufræðiáfanga sem birta mætti í námsskránni, annaðhvort óbreyttar eða með eðlilegum lagfæringum til að tryggja samræmi í heildarskipulagi. Við erum reiðubúnir til frekari viðræðna um þetta mál og jafnframt fúsir til að veita aðra aðstoð í tengslum við málefni stjörnufræðikennslu á Íslandi sé þess óskað.

Til frekari fróðleiks og umhugsunar fylgir einnig bréfinu lesefni er bregður nokkru ljósi á kennslu í stjörnufræði í dönskum og bandarískum skólum.

Fyrir hönd stjórnar Stjarnvísindafélags Íslands

Einar H. Guðmundsson

Einar H. Guðmundsson
formaður
(vinnusími : 694811)

Fylgiskjöl :

(a) Tillaga að lýsingum á tveimur áföngum í stjörnufræði.
(b) Frétt úr danska blaðinu Politiken, 23. nóvember 1989.
(c) Grein um stjörnufræðikennslu í bandarískum skólum.(Astronomy, september 1988).
(d) Tilkynning frá the Astronomical Society of the Pacific.

Lýsingar á tveimur áföngum í stjörnufræði fyrir framhaldsskóla
Tillaga frá stjórn Stjarnvísindafélags Íslands - 11. desember 1989

STJÖRNUFRÆÐI 103 — STJ 103

Almenn stjörnufræði

Undanfari Enginn

Áfangamarkmið
Meginmarkmið kennslunnar er að kynna nemendum heimsmynd nútíma stjarnvísinda og að vekja þá til umhugsunar um stöðu jarðarinnar í alheiminum og hlutverk mannkynsins í tilverunni. Þetta er gert með umfjöllun um helstu viðfangsefni, rannsóknaraðferðir og niðurstöður stjörnufræðinnar og með fræðslu um sögu hennar.

Lýsing fyrir námsvísa
Himinhvelið: Stjörnumerki, stjörnunöfn, hnitakerfi, stjörnuskoðun með berum augum og sjónaukum. Saga stjörnufræðinnar. Sólkerfið: Lýsing helstu hnatta, kenningar um uppruna. Sólstjörnur. Tvístirni, margstirni, stjörnuþyrpingar. Breytistjörnur. Æviferill stjarnanna. Vetrarbrautin: Stærð og lögun og fl. Alheimurinn: Vetrarbrautir og útþensla alheimsins. Kenningar um upphaf veraldar, þróun og endalok.

Ábendingar og athugasemdir
Áfanginn er almenn kynning á stjörnufræði. Hann er ætlaður nemendum sem hafa tiltölulega litla undirstöðu í stærðfræði og eðlisfræði (nemendur með meiri færni á þessum sviðum ættu frekar að taka STJ 203). Þess vegna skal leggja megináherslu á lýsingar og einfaldar myndrænar útskýringar og forðast flókna fræðilega umfjöllun. Dæmareikningur skal vera einfaldur og formúlum haldið í lágmarki. Mikilvægt er að hafa í huga að áfanginn hefur menningarleg markmið og sögulegra staðreynda skal þess vegna geta alls staðar þar sem við verður komið.
Stjörnukort, ljósmyndir, skyggnur, glærur, kvikmyndir, myndbönd og stjörnufræðiforrit fyrir tölvur eru mikilvæg kennslugögn fyrir áfanga af þessu tagi. Venjulegir handsjónaukar koma að góðum notum við stjörnuskoðun, en æskilegt er að nemendur hafi einnig aðgang að litlum stjörnusjónaukum, t. d. 3 - 4 þumlunga linsusjónauka eða 6 - 8 þumlunga spegilsjónauka.

STJÖRNUFRÆÐI 203 — STJ 203

Stjarnvísindi

Undanfari EÐL 203 eða EÐL 212

Áfangamarkmið
Markmið kennslunnar er að kynna nemendum heimsmynd nútímans og veita þeim staðgóða þekkingu á helstu grundvallarhugtökum, viðfangsefnum og rannsóknaraðferðum stjarnvísindanna.

Lýsing fyrir námsvísa
Himinhvelið: Stjörnumerki, stjörnunöfn, hnitakerfi, stjörnuskoðun með berum augum og sjónaukum. Sjónaukar og mælitæki. Saga stjörnufræðinnar. Sólkerfið: Lýsing helstu hnatta, kenningar um uppruna. Sólstjörnur: Eiginleikar (hiti, massi, stærð, ljósafl). Hertzsprung-Russell línuritið. Upphaf, þróun og endalok sólstjarna. Hvítir dvergar, nifteindastjörnur og svarthol. Breytistjörnur. Tvístirni, margstirni, stjörnuþyrpingar. Vetrarbrautarkerfið. Aðrar vetrarbrautir, venjulegar og virkar. Alheimurinn: Vetrarbrautir og útþensla alheimsins. Dreifing efnisins og gerð alheimsins. Kenningar um upphaf veraldar, þróun og endalok.

Ábendingar og athugasemdir
Þessi áfangi fjallar í öllum aðalatriðum um sama efni og STJ 103 (sjá áfangalýsingu hér að framan). Hann er þó fyrst og fremst miðaður við þarfir nemenda sem hafa góða undirstöðu í stærðfræði og eðlisfræði. Umfjöllunin er þar af leiðandi fræðilegri en í STJ 103 og notast er við hugtök og aðferðir eðlisfræði og stærðfræði eftir þörfum. Helstu kennslugögn fyrir áfangann eru hin sömu og talin eru upp í lýsingunni fyrir STJ 103.

Stjerne-lære i skolen

Af Leif Ahm

Astronomi får nu igen en plads i folkskolens undervisning, efter at faget har været ude i kulden siden 1975. Den nye læseplan for fysik og kemi, der ventes at træde i kraft næste skoleår, nævner astronomi som et af de i alt fem områder, undervisningen skal omfatte i løbet af 7.-9. klasse.

— Jeg kan ikke sige, hvornår astronomien genindføres på de københavnske folkeskoler, siger faginspektør Oscar Ekstrøm, Københavns Kommunale Skolevæsen. Men interessen blandt eleverne er stor, ikke mindst efter åbningen af det nye Tycho Brahe Planetarium. Jeg gætter på, at adskillige fysiklærere begynder så småt allerede i dette skoleår.

Også på andre punkter moderniseres undervisningen i fysik og kemi i fremtiden bl.a. med emnerne 'Det naturvidenskabelige Verdensbillede' og 'Liv og Miljø'.

A Free Classroom Resource for Grades 3 - 12

The Universe In the Classroom:
A Newsletter on Teaching Astronomy

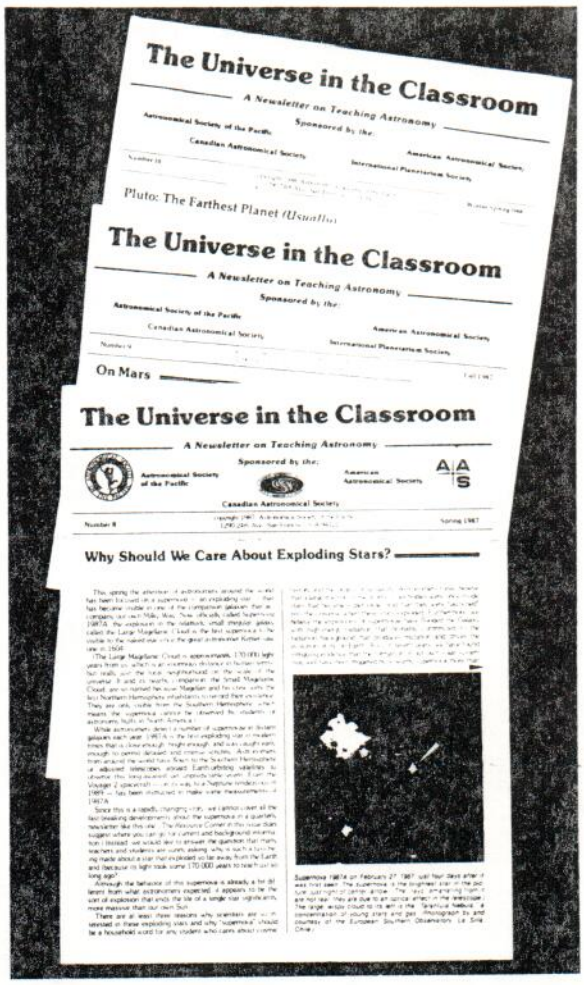
A free newsletter on teaching astronomy in primary and secondary schools is being offered by the four leading professional astronomy societies in North America. Designed to help teachers, curriculum specialists, and librarians include more astronomy in their classroom work, the newsletter is produced by the nonprofit Astronomical Society of the Pacific and is co-sponsored by the American Astronomical Society, the Canadian Astronomical Society, and the International Planetarium Society.

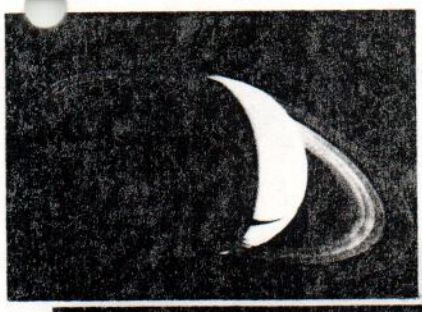
Each quarterly issue features:

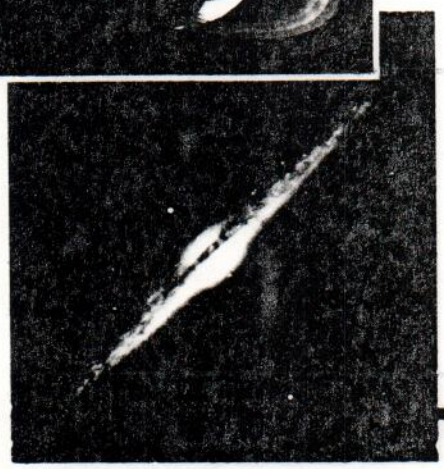
- clear nontechnical articles on new developments in the exploration of the universe
- practical classroom activities for teaching astronomy
- specific suggestions for the best written and audio-visual resources on astronomical topics.

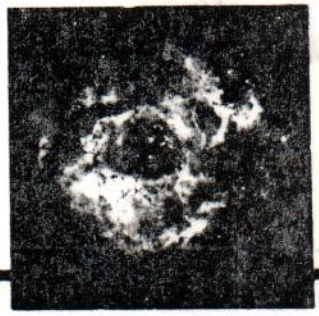
Articles focus on a variety of interesting subjects in astronomy, such as the exploration of the planets, exploding stars, the search for life elsewhere, the Big Bang, the difference between astronomy and astrology, and much more.

No background in astronomy is assumed of the reader; in fact the sponsoring societies particularly want to encourage teachers who have *not* had much training in science to write for the newsletter.









To be put on the mailing list for future issues, teachers or school librarians should write *on school stationery* and identify the grade level they teach.

Write to:

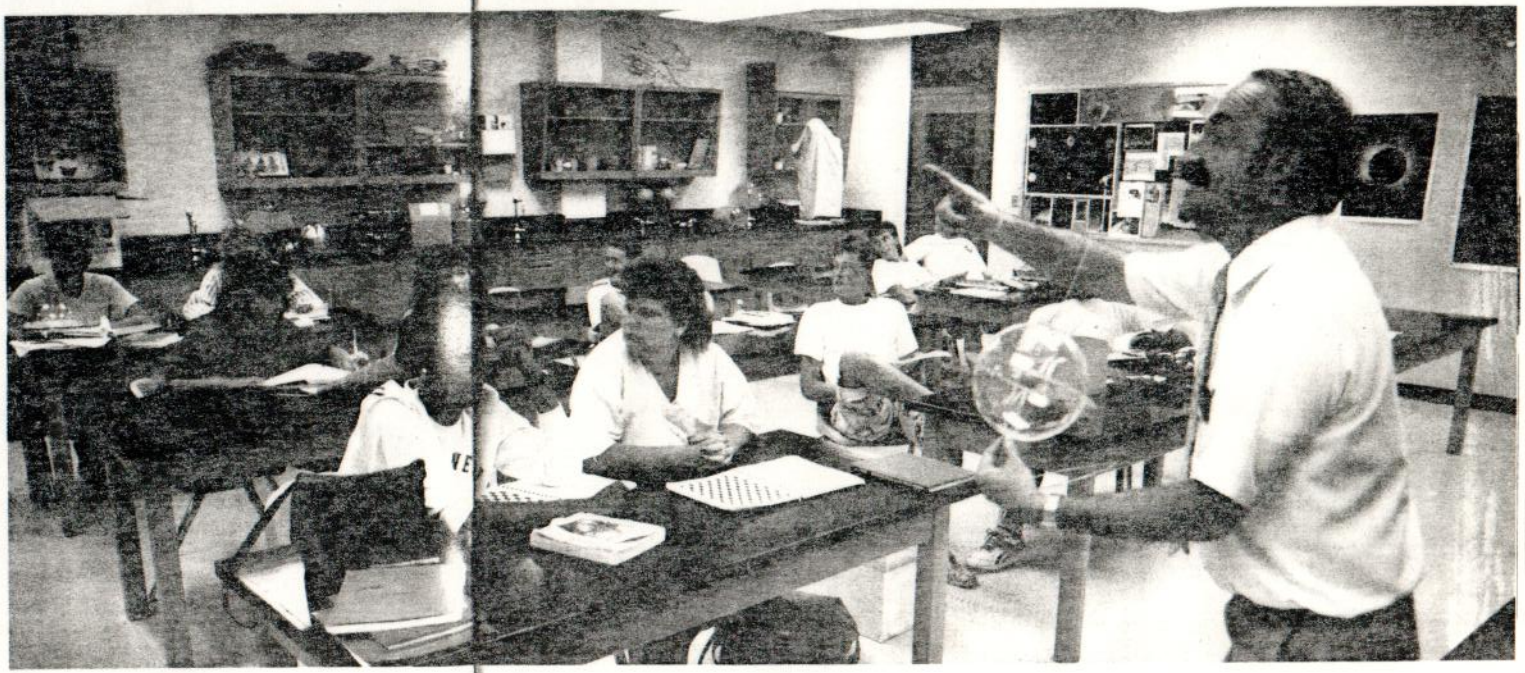
Astronomical Society of the Pacific
Teachers' Newsletter, Dept. N
390 Ashton Ave.
San Francisco, CA 94112

(The Teachers' Newsletter project is supported in part by grants from the sponsoring societies, the V.M. Slipher Fund of the National Academy of Sciences, AUI/Nat'l Radio Astronomy Observatory, Lockheed, and Apple Computers.)

ASTRONOMY IN OUR SCHOOLS

A grassroots movement is getting astronomy back into the classroom.

by Stephen Cole



Astronomy was expelled from American schools in 1894, thrown out by the educational reform spirit of the day that promoted practical "education for life." Within a decade astronomy had virtually disappeared from the classroom. The decline was so pervasive that in 1920 W. W. Campbell, director of Lick Observatory, chided U.S. educators for producing a generation of high school graduates that could "tell us all about the lights in our houses, but not one word about the lights in our sky."

The effect of that expulsion still endures. High school graduates today learn less about the lights in the sky than their great-grandparents did one hundred years ago. Science teachers are not trained in the fundamentals of astronomy in college. Textbooks and classroom materials on astronomy are hard to come by.

But there is reason to believe that astronomy is about to rise again. A growing network of educators around the country is providing workshops for teachers. Professional astronomers are developing training programs and materials for elementary and secondary teachers. And the federal government is funding the development of a high school astronomy course.

This resurgence of interest in astronomy is part of the current educational reform movement that calls for improved scientific literacy. With national economic health more and more dependent on technical expertise, a scientifically proficient populace is essential. According to a recent international survey of student achievement in science, U.S. ninth graders placed fifteenth out of the students polled in seventeen countries including Japan, Great Britain, and Canada.

While no one is claiming that the balance of trade will suddenly improve if more students know what the ecliptic is, astronomy advocates do believe the country would benefit from astronomy's ability to engage student interest in a wide range of sciences.

"Astronomy is unique among the sciences," says Jeanne E. Bishop, textbook author and planetarium director for the public schools in Westlake, Ohio, "because so many other disciplines — chemistry, physics, biology, geology — are incorporated in it. Astronomy provides a good understanding of science as a whole."

"I'm not sure anything else would have grabbed my attention in school like astronomy did. I'm a scientist today because of astronomy," says Ken Willcox, a research chemist and vice president of the Astronomical League, the national association of amateur astronomers. "Astronomy is a good way for kids to test their interest in science as a career."

Judging by the low student enrollment in high school science courses, not many kids are currently testing their interest in science. During the last two years of high school the number of students taking science courses drops from one half to one third of the class. Chemistry and physics are taken by only one third of high school students. The scientific literacy of American youth won't be improved if students are not in science classes.

Proponents of astronomy education maintain that many more students would take science in high school if astronomy were one of the choices. Physics is currently taught in 80 percent of the nation's high schools, chemistry in 90 percent, and astronomy in 8 percent.

"Astronomy is the right subject for students who don't elect physics or chemistry in high school," says Philip Sadler, project director of the federally funded high school astronomy curriculum program, Project STAR. "It is a very visual science and it intrigues most students. When it is offered, kids take it. In a way astronomy is a product that fits today's education market."

It may be hard for even diehard amateur observers to imagine astronomy ever gaining the status of the big three sciences — biology, chemistry, and physics — in the nation's high schools. These subjects have such an aura of permanence that it somehow feels presumptuous to think another science could join their ranks.

But these sciences did not rise to prominence through some sort of academic natural selection in which the superior subjects prevailed. They dominate today because that's what educators wanted to teach in the 1890s. If educators in the 1990s want to teach something else, they can decide to do so.

Prior to 1894, astronomy was widely taught in the United States as part of "natural philosophy." But an influential report on secondary school studies by the National Council of Education put an end to that. The report, produced by a committee of educators led by Harvard University president Charles W. Eliot, sought to standardize high school curricula and college entrance requirements.

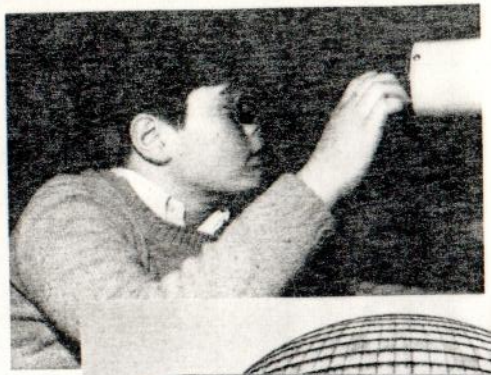
The report recommended that physics and chemistry should be required for college admission and that astronomy should not. The report's recommendations were widely adopted, and as a result, astronomy instruction quickly disappeared. From 1895 to 1910 the number of college-bound students who had studied astronomy dropped by 90 percent.

The situation did not improve until the 1950s when the shock of the Soviet *Sputnik* launch brought a surge of interest in science education. Astronomy made some gains as federal funds poured into science curriculum development programs like Harvard Project Physics, which contained some astronomy. The construction of school planetariums was also supported by federal dollars, and hundreds of planetariums sprang up in the 1960s. But when funding for these programs dried up in the 1970s, interest in astronomy also dried up.

Today astronomy can be found in elementary and secondary science curricula, but it is spread very thinly, so thinly that many students leave school without any significant course work in astronomy. Students first encounter astronomy as part of the Earth science curriculum between third and sixth grade. Separate astronomy courses are offered in only 5 percent of U.S. middle schools and in less than 10 percent of high schools.

As part of Earth sciences, astronomy shares class time and textbook chapters with geology, meteorology, and oceanography. Although astronomy usually receives one quarter of the year, the astronomy unit often shrinks to as little as two weeks.

Earth science is not, however, like reading, writing, or arithmetic, a subject students will necessarily encounter before they graduate from high school. "It is a neglected science," says Sharon Stroud, past president of the National Earth Science Teachers Association and a science teacher at Widefield High School in Colorado Springs. Recent surveys have found that Earth science is taught at the elementary level in less than half the states



HANDS-ON ASTRONOMY activities like using a telescope and building a pinhole camera to observe a solar eclipse are part of the educational opportunities at Chicago's Adler Planetarium.

ASTRONOMY SHARES PAGES in elementary and middle school Earth science textbooks with geology, meteorology, and oceanography.

and that there is no Earth science course offered in 70 percent of U.S. high schools.

If a student does receive instruction in Earth science, he will probably first learn about astronomy as a fourth grader. He will learn about the Sun-Earth-Moon system and seasons, tides, and eclipses; he will be able to name the nine planets. In middle school he will study the planets in more detail, learn about the different types of stars, and begin to think about relative distances in the solar system and the universe. If he takes an Earth science course in high school, he'll study the intricacies of stellar evolution and planetary motion.

An important — and usually memorable — component of astronomy education, especially in the lower grades, is the planetarium. About five hundred school districts in the United States have their own planetariums. Planetariums are also found in most major metropolitan areas. And if neither of those is available, a school can set up an inflatable planetarium in the gym.

"Planetariums have played a major role in improving astronomical literacy," says Jeanne Bishop, former president of the International Planetarium Society. Bishop's involvement with planetariums dates back to the planetarium her father, a university physics professor, built in the family garage when she was growing up.

"You don't get the geocentric picture of what is happening in space anywhere else but in the planetarium," says Bishop. "Without that ability to switch points of view between the geocentric and what's really happening, students grow up with a strange idea of the concept of seasons and lunar phases."

Making that conceptual jump between what a student sees in the sky and what is shown in a textbook diagram can be a very difficult task. Understanding how the Earth's movements affect our view of the sky can be a major stumbling block for students. "I'm amazed at what kids don't know," says Russ Harding, planetarium director for the public schools in Norwalk, Connecticut, and head of the Association of Astronomy Educators. "They often have no idea that there are seasonal changes in the sky, no idea that if you traveled south you'd see a different sky."

According to interviews conducted by Project STAR researchers looking into student preconceptions about astronomy, such conceptual problems are very common. "The misconceptions that students — and even adults — have are so striking and so worrisome that the fundamental focus of our whole project is to try to change some of these," said project director Sadler. Common beliefs include the view that Earth's shadow causes lunar phases, that stars don't move in the sky, and that the planets are fairly close together.

Educators lobbying for wider acceptance of astronomy in our schools have a lot of obstacles to overcome. The historical legacy of the last century has left little time for astronomy in the classroom; misconceptions about astronomical concepts have gained wide circulation. But the hardest problem to overcome may be that today's science teachers lack experience teaching astronomy.

"A lot of Earth science teachers are not qualified to teach Earth science," says Stroud, noting that many Earth science teachers are biology teachers who have been assigned an additional course. Although high school science teachers generally have an undergraduate degree in science — and one third have taken a college astronomy course — middle school science teachers have less training and elementary teachers may have had no science background.

In a National Science Foundation survey of science education released earlier this year, only 15 percent of elementary school teachers reported that they felt very well qualified to teach Earth/space sciences, compared to 27 percent who felt competent in the life sciences.

According to Jeanne Bishop, new teachers are not well trained in astronomy because their college instructors don't have an adequate background in astronomy. "This is a cyclical problem we're still trapped in today. Before the 1890s everyone who taught elementary school or high school had taken courses on natural phenomena. But when high schools from 1900 through 1950 dropped astronomy, these teachers didn't get much background in it."

Astronomy classes are not available to students in 90 percent of U.S. high schools.

The long-term solution to reversing this cycle of astronomical ignorance would have to involve changing the teacher training process, says Bishop, although she acknowledges that this is unlikely. "I'd like to see a course called 'elementary descriptive astronomy' become a college requirement for all teachers, no matter what discipline they specialize in. If the course did nothing more than turn teachers on to the beauty of the subject, astronomy would trickle down through many different disciplines into students' education."

Despite the magnitude of the problem, many astronomy educators are doing what they can at the grassroots level to train teachers in astronomy. "You have to push the educational community into this," says Russ Harding, who, as head of the Association of Astronomy Educators, gives workshops at national teachers' conferences and publishes a newsletter of astronomy activities for teachers at all grade levels. The National Earth Science Teachers Association also offers astronomy workshops at teacher conferences and maintains a state-by-state network of resource people for teachers to contact.

"Teachers are very thirsty for information," says Harding. "But they say they don't have a lot of background in the area, that they don't know where to start." Harding's answer is to give teachers classroom activities that teach solid science but do not require an extensive background in astronomy.

"Many teachers are afraid to teach astronomy because they're worried that their students will know more about it than they do," says Andrew Fraknoi, executive officer of the Astronomical Society of the Pacific, the one hundred-year-old educational organization that has sponsored ten annual teacher workshops.

These workshops have attracted two hundred teachers each year for two days of lectures on astronomical fundamentals as well as the latest research news and demonstrations of classroom activities. This year's work-

shop, held this summer in conjunction with the society's annual meeting in Victoria, British Columbia, included demonstrations of how to make a dry ice comet, lectures on supernova 1987A and Mars, and advice on buying binoculars.

"We encourage teachers to take the materials we give them and hold workshops in their own districts," said Fraknoi. "Since we started these workshops, there have been a hundred secondary workshops held across the country."

The workshops also spawned a newsletter, "The Universe in the Classroom," which the Astronomical Society of the Pacific sends out to 20,000 teachers. Each issue contains an article on a major science topic and a related classroom activity and bibliography. Pluto, Mars, and supernovae have been recent topics covered in the four-page quarterly newsletter.

Many science teachers lack adequate training in the basics of teaching astronomy.

The grassroots teacher training activities are not just coming from teachers and groups already committed to astronomy: corporations are also sponsoring workshops in the name of educating the next generation of scientists and technicians. Since 1982 Phillips Petroleum Company has sponsored an annual science teachers workshop in which Phillips scientists give talks on chemistry, geology, physics, and astronomy for three hundred teachers at its headquarters in Bartlesville, Oklahoma.

"The emphasis is hands-on science," said Phillips research chemist Ken Willcox, who gives the astronomy workshop. "We want to give teachers things they can do in the classroom to generate interest."

At this year's workshop, which focused on elementary school science, Willcox demonstrated how Styrofoam balls can be used to simulate lunar phases and eclipses and how relative solar system distances can be experienced by students using a Ping-Pong ball (for Earth) and a nice, straight local road ten miles long (the distance to Pluto).

Teachers, however, need more than creative classroom lessons to be effective: they also have to motivate students to learn. A unique pilot program developed by the Charleston County, South Carolina, school district and NASA emphasizes getting teachers excited about astronomy through direct involvement in scientific research. The goal is to instill in students the same enthusiasm the teacher experienced.

In August 1987 six teachers from Charleston County schools flew as guests aboard NASA's Kuiper Airborne Observatory (KAO) and photographed the Milky Way through a 36-inch telescope mounted in the jet. The photos have since been incorporated by the teachers into instructional slide programs that will be introduced districtwide in the 1988-89 school year. The enthusiasm the teachers brought back has already started to work.

"It's exciting for kids to see their teachers doing this kind of thing. They feel proud and really involved in what *their* teacher did," says Sharon Brower, science coordinator for the Charleston county schools.

"I was so enthusiastic when I got back," says eighth grade Earth science teacher Nancy Parsons, "that it had to stimulate the students more. They wanted to know all about what it was like up there."

The six teachers — none of whom had previous training in astronomy — underwent eight months of training in the basics of astronomy. Because the objective of the KAO flight was visual and infrared photography, the teachers received training in all aspects of astrophotography — use of filters, types of films, processing, and printing — and learned how to use a telescope and the celestial coordinate systems. The training was provided by a local planetarium and amateur astronomy groups and coordinated by James Nicholson of the Medical University of South Carolina.

The two KAO flights flew out of NASA Ames Research Center near San Francisco. The teachers piggybacked their cameras on the KAO telescope while astronomers observed the Milky Way. When the flights were over, the astronomers took away their computer data and the teachers took away their photos.

Although no second teacher training flight is currently planned, NASA is evaluating the project for possible use with other school districts.

The movement to improve astronomy education in the nation's elementary and secondary schools has grown beyond the grassroots efforts of teacher groups and individual school districts in recent years. Now significant contributions are being made by the professional astronomy community. The American Astronomical Society this year initiated workshops for local teachers at its two annual meetings. And, beginning this year, one of the country's newest astronomical institutions — the Space Telescope Science Institute in Baltimore, Maryland — joined the cause with a new educational affairs division and a week-long teacher workshop.

"We could become a major force in educational excellence in astronomy across the nation," says Eric Chaisson, head of the institute's educational and public affairs division. "Once the *Hubble Space Telescope* is in orbit, we'll be able to offer more workshops and open them up nationally."

At the inaugural workshop held in June, Chaisson gave twenty-five Maryland high school astronomy teachers an inside look at how science is done. Using hands-on laboratory activities in spectroscopy, optics, and lasers, Chaisson hopes to give teachers a solid background in both the fundamental concepts and the more advanced areas of astronomy.

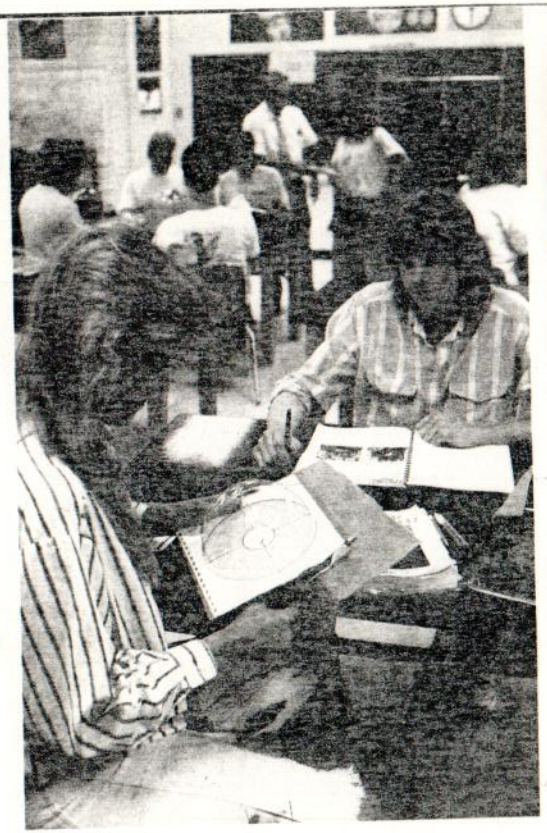
"The teachers want substance, they want the science," Chaisson says. "They don't feel they're trained well enough in modern astronomy to satisfy their students. I'm just trying to give teachers what they want: an update on modern astronomy."

Chaisson is also planning to produce instructional materials using state-of-the-art computer graphics and video technology. Plans are under way to produce posters, hands-on activities, and slide presentations, based on the workshop held this summer.

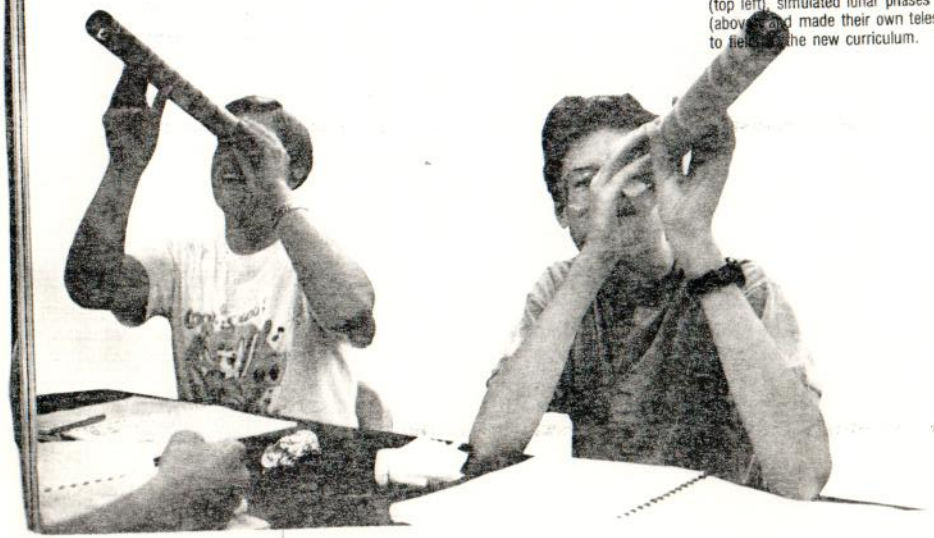
Perhaps the most influential contribution astronomers are making to astronomy education is under way at the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts. Supported by a grant from

A FLYING CLASSROOM is where South Carolina teacher Nancy Parsons learned about the excitement of science. Parsons and five other teachers flew aboard NASA's Kuiper Airborne Observatory with astronomers as part of a teacher training program in astronomy.

THE ARTIFICIAL SKY inside a planetarium, even one that inflates under the ropes and hoops of a school gymnasium, allows students to see how the complex movements of the Earth, Sun, and Moon determine what they see in the night sky.



A NEW ASTRONOMY COURSE for high schools, being developed at the Harvard-Smithsonian Center for Astrophysics, stresses hands-on activities. Wisconsin science teacher Gary Sampson's student's built celestial spheres (top left), simulated lunar phases (above) and made their own telescopes to field-test the new curriculum.



the National Science Foundation, astronomers at the center are working on Project STAR, a program to develop a year-long astronomy course for the nation's high schools.

With no high school-level astronomy textbook in print, teachers who offer astronomy courses have had to create their own curriculum from whatever resources they could find. Project STAR's goal is to develop an astronomy textbook and workbook, along with additional printed materials, videotapes, and software, and have those materials ready by the fall of 1991.

Curricula developed by university scientists are nothing new to American high schools: university-developed courses in biology and physics have been widely used for years. The Project STAR curriculum is being developed by a panel of scientists and a group of Boston-area high school teachers. Since the project began in 1986, Project STAR staff, scientists, and teachers have met each summer to test and revise the curriculum. The materials created to date were reworked this July after being tested nationwide in twenty-five schools during the 1987-88 school year; this fall the revised curriculum will be fieldtested again.

The Project STAR curriculum takes a nontraditional instructional approach. Instead of a textbook and lecture course that surveys many concepts, Project STAR focuses on the mastery of a few fundamental concepts through a series of hands-on activities. The goal is to give students a meaningful introduction to how science works — the STAR acronym stands for "science teaching through its astronomical roots" — instead of a cursory introduction to many astronomical facts.

The STAR curriculum will be made up of three units: the nature of light, which will focus on how light is used to reveal the temperature and size of celestial objects; the laws of nature, particularly the laws of motion observed in planets, stars, and galaxies; and orientation in space and time, in which students make the conceptual leap from an Earth-centered view of the universe. Only the space and time unit is completed so far.

The activities in this unit include making a telescope from paper-towel tubes and two plastic lenses (total cost: 50 cents) to observe lunar features and creating an artificial star from a flashlight and a piece of optic fiber to estimate stellar distances. The most popular project among students, according to project director Philip Sadler, was constructing a celestial sphere from two clear plastic hemispheres.

"It seemed odd to the astrophysicists working on this project that this two thousand-year-old concept was so popular," said Sadler. "But it's definitely the glue that holds together a lot of concepts about the sky."

Three years from now the Project STAR curriculum will be published and ready for use, but whether or not it ever finds its way into the hands of students is another question. In a democratic educational system where textbooks may be recommended to local school districts by state education departments but not required, the existence of good materials does not guarantee the widespread use of these materials. Will school districts across the country be interested in adding an astronomy course, given the shrinking pool of science teachers and the lack of training in astronomy?

Recognizing this problem, Irwin Shapiro, Project STAR principal investigator and director of the Harvard College Observatory, has proposed another project to the National Science Foundation that would give astronomy training to teachers at all grade levels.

The program, titled "Support Program for Instructional Competency in Astronomy," would use Project STAR staff to systematically train a national network of high school astronomy teachers who will in turn train teachers in their own communities. Pending approval by the NSF, the program will begin early next year.

Each summer for four years, thirty-two teachers will attend a four-week workshop at the Center for Astrophysics to learn about the latest science education theories and get hands-on experience with classroom materials. Over the duration of the program 128 teachers will be trained at these workshops. During the school year following the summer workshop each teacher will give two astronomy workshops, one within his or her own district and one outside of it, and reach an estimated forty-five additional teachers.

Enrollment in high school astronomy courses is predicted to increase tenfold in the 1990s.

Teachers will be trained to give a number of workshops on how to run a star party, use star maps and the celestial sphere, and effectively teach astronomy. Each teacher will also maintain a local "information office," either a post office box or a computer bulletin board, that workshop participants can write to for advice.

The program will also develop a network of amateur astronomers in cooperation with the Astronomical League that will "adopt an astronomy class" and offer evening observing sessions for the class. "Many teachers, especially new astronomy teachers, would like to have star parties," says Sadler, "but few have ever done that with groups of kids. Many amateur groups have."

Sadler is confident that the combined punch of a complete high school curriculum package and an ongoing teacher support program will dramatically increase the amount of astronomy taught in U.S. schools. "Right now only about 50,000 students take astronomy in high school each year, compared to the more than half a million who take physics. We can get that up to half a million in astronomy as well."

In the 1990s we may see the end of the cycle of astronomical ignorance that has been perpetuated in our school system for nearly a century. We will have to wait, however, to see whether that produces a more scientifically literate America.

But we can be certain that the students who do study astronomy will gain at least one benefit from their efforts, something that has little to do with careers and academic achievement. "If you can understand your place in the universe and appreciate the immense scale of that," says Jeanne Bishop, "you can begin to understand the unique kinds of abilities that humans really have compared to the mechanical universe. Without that perspective, I don't think that you can be a well-educated human being." □